Chapter 1
Introduction

Section I
General

1-1. Purpose

This manual presents the results of research, design studies, and operation experience as guidance for the hydraulic design of navigation locks.

1-2. Scope

The guidance is limited to lock types that are considered design options by the U.S. Army Corps of Engineers (CE). Other designs, such as mechanical lifts and water slopes occasionally used in Europe, are discussed in Appendix G, but not discussed in detail since they have not been feasible options for waterways within the United States. Detailed theory, computer programming, and computer codes are not presented; however, sources of these types of information are noted. The site, structure, hydraulic system, and operation of most existing CE lock configurations are summarized. Laboratory and field studies and other information data sources pertinent to these locks are identified. The overall broad scope of materials specifically addresses the following two design circumstances.

a. Existing locks. General information concerning hydraulic factors that lead to safe, efficient, and reliable lock performance is useful for the repair or rehabilitation of existing locks. Many existing locks are not current state-of-the-art designs; design guidance for obsolete systems is not presented.

b. New locks. Detailed information regarding state-of-the-art hydraulic systems is directed toward new or replacement locks. General information regarding parameters used as the basis for design as well as specific information regarding function, structure, performance, and operation of modern locks is included.

1-3. Applicability

This manual applies to all HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having responsibilities for the design of civil works projects.

1-4. References

Appendix A groups references into three lists: the Required Publications and Related Publications consisting of CE-Sponsored Lock Hydraulic System Study Reports and General Bibliography. Each list is discussed below.

a. HQUSACE Publications. Applicable Corps guidance including Engineering Regulations, Engineering Manuals etc., are listed in numerical order in Appendix A, paragraph A-1. References throughout the manual use the document number.

b. CE-Sponsored Lock Hydraulic System Study Report. These reports are U.S. Army Corps of Engineers sponsored laboratory studies of lock systems administered by Waterways Experiment Station (WES), Bonneville Hydraulics Laboratory (BHL), or St. Paul District (STP). References throughout the manual begin by a number (e.g. item 01, item 02, ..., item 86). Corresponding references are listed chronologically in Appendix A, paragraph A-2.

c. General Bibliography. These references include other general literature relevant to hydraulic design of navigation locks or applicable hydraulic topics. References throughout the manual begin with a letter (first letter of the author’s last name) followed by a number (e.g., A1, A2, B1, B2, etc). Corresponding references are listed in alphabetical order by author in Appendix A, paragraph A-3.

1-5. Explanation of Terms

Symbols used throughout this manual are defined in Appendix H and, as far as practical, conform to the American Standard Letter Symbols for Hydraulics (item A4). Symbols are also defined at the first use within the text.

1-6. Technical Data

Plates at the end of the appropriate chapter provide design guidance and details for hydraulic design. Data sources are identified. A summary of existing CE locks including various arrangements of hydraulic features is presented in Appendix B and in more detail in the CEWRC-NDC Waterling Bulletin Board System (Navigation and Dredging Data and Reports, Lock Characteristics Data, Physical Characteristics Report).

Section II
Technical Coordination

1-7. General

Specific services are available to the designer in subject areas complementary to the hydraulic design. These are not, in general, described in this manual. Centers of expertise addressing environmental topics, hydropower, navigation, etc., may be located by query to HQUSACE.

1-8. Automatic Data Processing (ADP)

The development and management of computer-based capabilities is an ongoing process within the CE. ADP coordinators at HQUSACE, Division, District, and Research offices may be queried with regard to program and equipment status. The WES Automatic Data Processing Center (ADPC) Computer Program Library (WESLIB) provides computer information and services to CE Divisions and Districts. One service is the *C*onversationally-*O*riented *R*eal-Time *P*rogramming *S*ystem (CORPS), which provides a set of proven engineering applications programs that can be accessed on several different computer systems by engineers with little or no computer training. A catalog of WESLIB programs is maintained (updated as needed) and distributed to ADP users throughout the CE. References to programs available to the lock designer are noted in this manual by the CORPS program number.

1-9. WES Capabilities and Services

WES has capabilities and furnishes services in the fields of hydraulic modeling, analysis, design, and prototype testing. Expertise has been developed in the areas of water quality studies, mathematical modeling, and computer programming. Procedures necessary to arrange for WES participation in hydraulic studies of all types are covered in Engineer Regulation (ER) 1110-1-8100. WES also has the responsibility for coordinating the CE hydraulic prototype test program. Assistance during planning and testing is included in this program.

1-10. Design Memorandum Presentations

Design memoranda should contain sufficient information to ensure that the reviewer is able to reach an independent conclusion as to the design adequacy. For convenience, the hydraulic information, factors, studies, and logic used to establish such basic features as type of lock intake, manifold system, outlet, valves, etc., should be complete and readily identifiable within the hydraulics presentation. Appurtenant items such as debris barriers and emergency closure procedures should be presented in similar detail. Operating characteristics over the full range of hydrologic, navigation, and other site-specific boundary conditions should be provided.

Section III
Project Function

1-11. General

The function of a lock is to provide safe passage for navigation between two pools not at the same water level. The difference in water level may exist naturally (as in the Panama Canal Locks) or be developed for economic reasons (such as hydropower at Bonneville Lock on the Columbia River or navigation at Bay Springs Lock on the Tennessee-Tombigbee Waterway). Other considerations (economic, environmental, geotechnical, etc.) are constraints to the design process. Site-specific constraints, including those that for practical reasons are beyond the scope of this manual, should be clearly stated in hydraulic presentations.

1-12. Primary Components

All lock designs presented in this manual contain the four primary components given below and shown schematically in Figure 1-1.

a. Upper approach. The canal immediately upstream from the lock is referred to as the upper approach. The guide wall serves to align and to guide a downbound tow into the lock chamber and is usually a prolongation of one wall of the chamber. The guard wall provides a barrier that prevents the tow from entering an area having hazardous currents or potentially damageable or damaging structures. The term guide-and-guard wall may be used when the combination of functions results in deviations from usual guide wall design practice. Guidelines for approach channel design are included in EM 1110-2-1611.

b. Lock chamber. The downbound traffic is lowered to lower pool and the upbound traffic is raised to upper pool within the lock chamber. The upper and lower gates are movable barriers that can be opened to permit a vessel to enter or exit the chamber. Sills, which extend across the lock chamber at the base of the gates, provide a surface for gate closure and are the structural limits for navigable depth in the lock. Lock wall appurtenances are

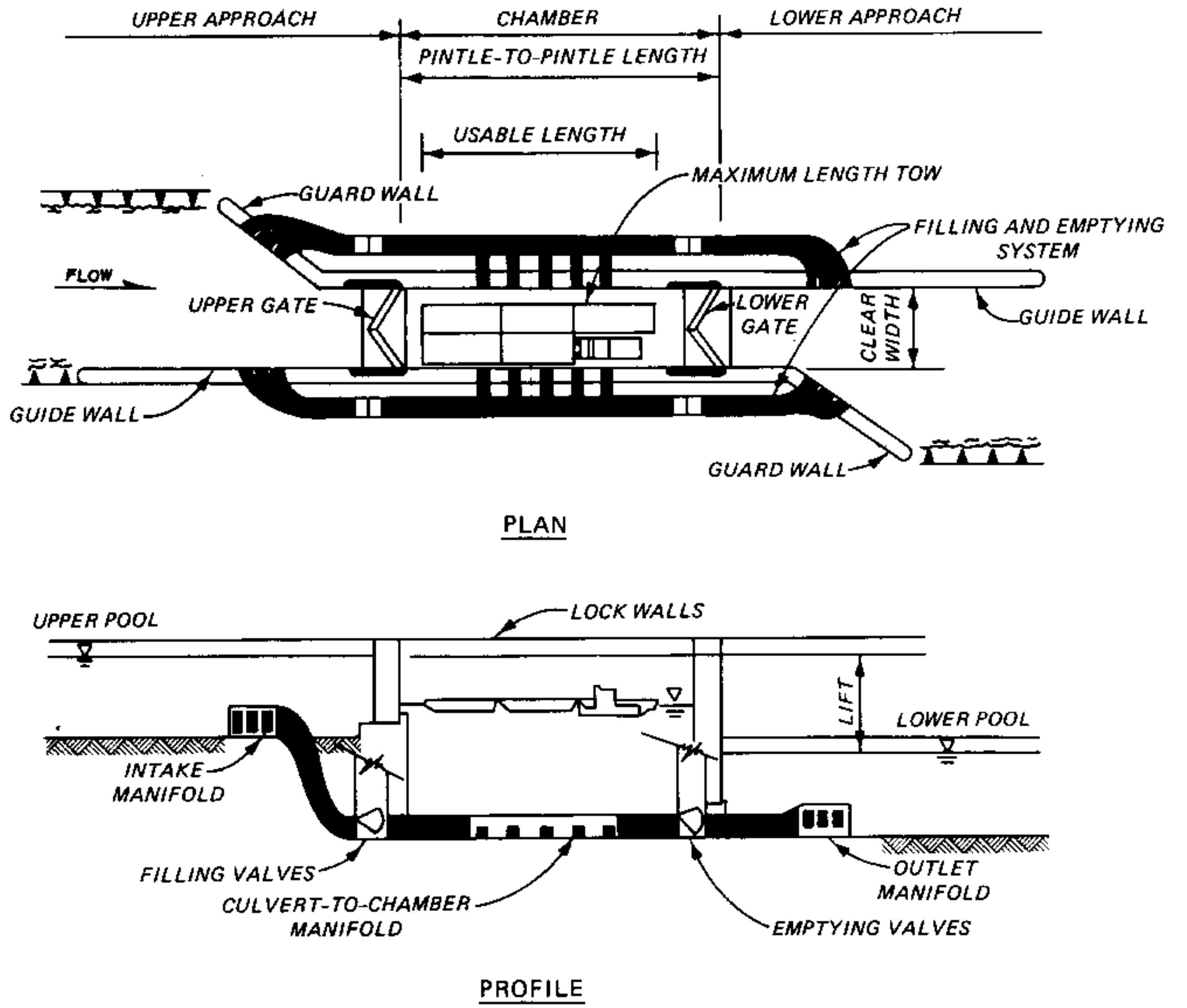


Figure 1-1. Common lock features for a lock with culverts in the sidewall

recessed so that the clear width and the usable width are identical. Conversely, because of clearances provided for gate operation and for longitudinal tow drift, the usable length of the chamber differs from commonly specified nominal lengths, i.e., less than the pintle-to-pintle length shown in Figure 1-1. The difference between upper and lower pool elevations is termed lift.

c. Filling and emptying system. For a lock filling operation, the emptying valves are closed. The filling valves are opened. Flow enters the intake manifolds and exits by means of the culvert-to-chamber manifolds into the lock chamber. For emptying, the filling valves are closed and the emptying valves are opened. Flow enters the culvert-to-chamber manifolds and exits by means of the outlet manifolds. Many differences are possible and acceptable between the idealized system shown in Figure 1-1 and an actual design. Intakes and outlets may not be located directly in the approach canals; the number, general shape, and location of the manifolds vary between designs; the filling-and-emptying system may be separated; etc.

d. Lower approach. The canal immediately downstream from the chamber is referred to as the lower approach. Guide, guard, and guide-and-guard walls are used and defined similarly both upstream and downstream from the lock (EM 1110-2-1611).

1-13. Special Needs

Operation and maintenance considerations (as well as more site-specific topics such as environment, relocations, and geotechnical factors) require additions to the schematized navigation lock shown in Figure 1-1. Construction cofferdams, emergency closure devices, surge suppression pools, and impact barriers are examples of more common special needs that are studied during hydraulic design of navigation locks.

1-14. Classification Systems

Two methods are used to classify lock projects.

a. Project classification (lift). etc.) within the chamber to obtain smooth filling and emptying. In addition, higher lifts require the filling-and-emptying system to be designed such that cavitation, abrasion, flow-induced vibration, and other liabilities associated with high-velocity flow do not occur. A lock project is therefore viewed by lift as being in one of four categories as identified from studies of existing projects (Plate 1-1). The categories are listed in Table 1-1.

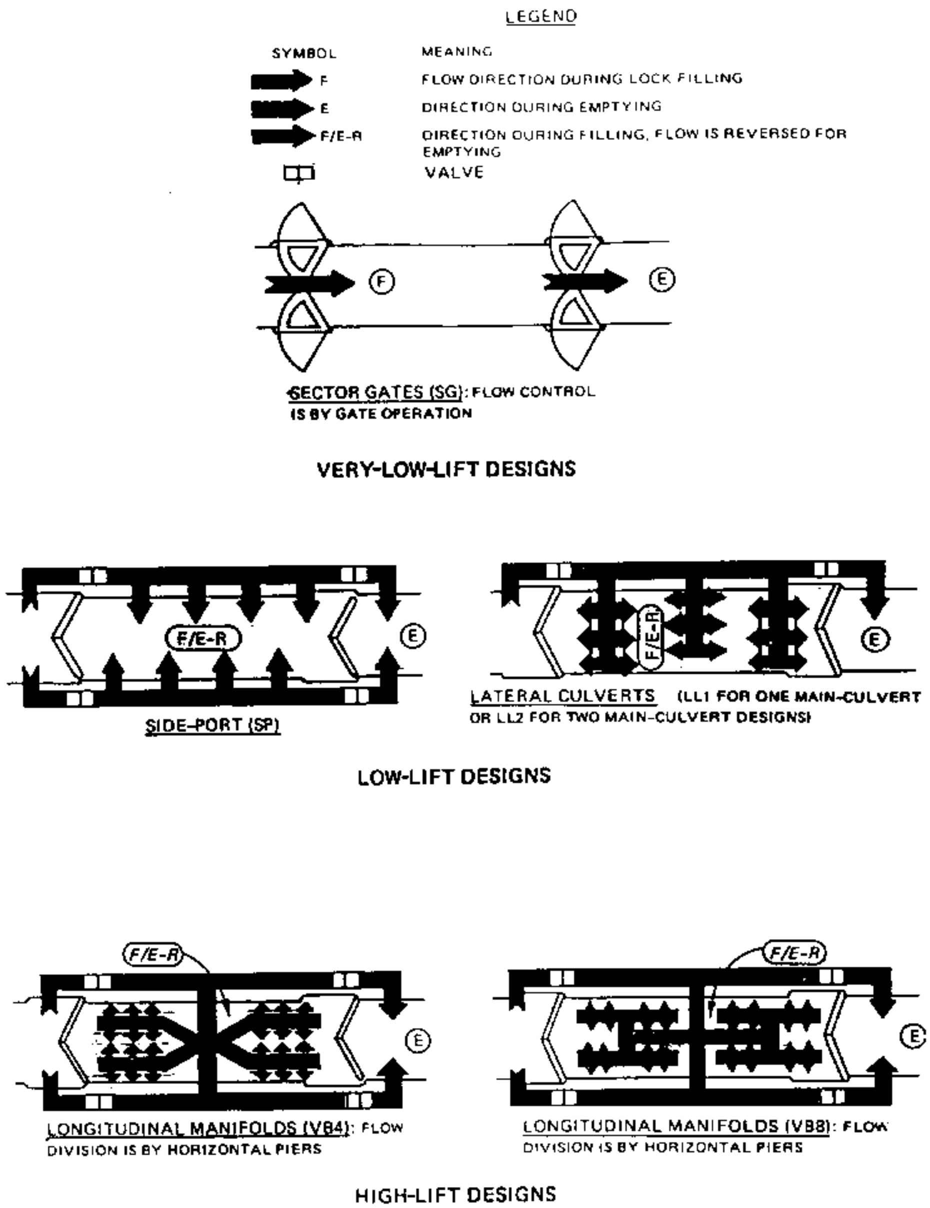
b. Design classification (filling-and-emptying systems). Specifications regarding within-chamber manifolds, baffles, and other structural elements are derived from laboratory testing and prototype experience. Small variations in these elements, particularly for high-lift locks, may cause significant surface currents or local turbulence unfavorable to lock operation. Two specific design alternatives are suggested in this manual for each range of project lifts. Schematics of the suggested designs are shown in Figure 1-2 and comments regarding their applicability are included in Table 1-1. Higher lift designs function well at lower lifts; however, increased costs are also associated with higher lift designs.

1-15. CE Lock Operating Experience

A list of most existing CE locks is in Appendix B. Plate 1-1 illustrates the historic trend away from certain designs (i.e., loop culverts and valves-in-gates) reflecting economic or operational liabilities. Substantial experience with sector gate (very-low-lift) and side-port (low-lift) designs is evident. One each of the longitudinal manifold (vertically divided flow by means of horizonal splitters) designs suggested for high-lift projects is in operation. An extensive summary of devices and concepts used in earlier (pre-1940) CE navigation locks and dams is available (item U1).

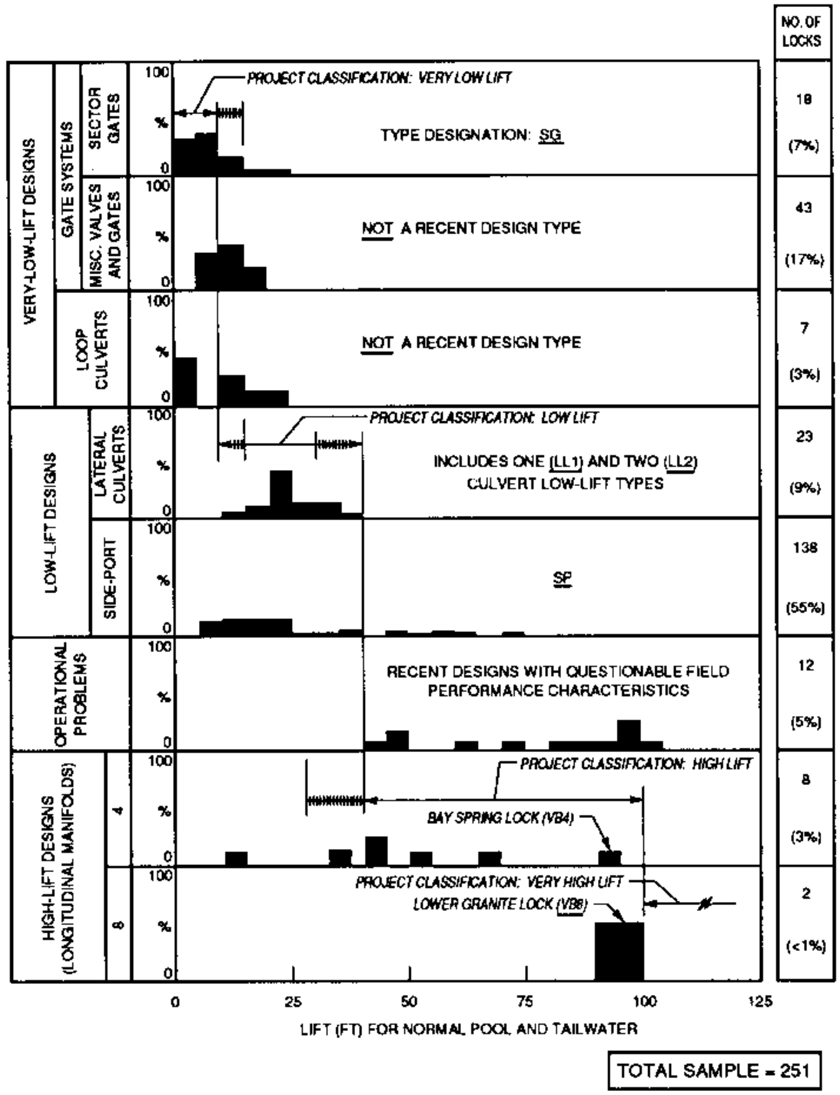
Table 1-1
Classification of Projects by Lifts

Range of Maximum Design Lift (ft to ft)	Project Classification	Percent of Corps Locks	Suitable Design Types
$0^{\pm}$ to 10	Very low lift	25	End filling-and-emptying systems are suitable. Each of the three general types (gate, valve(s)-in-gate, and loop culvert) can normally provide satisfactory chamber conditions. Choice of type is influenced by economic, operational, and layout factors. The sector gate has been used exclusively for CE very-low-lift designs since 1950.
10 to 30/40	Low lift	60	Wall culverts with side ports (side-port systems) are generally best suited for lifts below about 30 ft. The auxiliary system using lateral manifolds is suitable for low-lift projects requiring one culvert lock operation. Simplified high-lift designs have been model-tested for lifts in the 30- to 40-ft range.
30/40 to 100	High lift	15	Longitudinal manifold systems are suitable. Choice of type (4 or 8 manifolds) is influenced by economic and layout factors. Recent designs subdivide the flow by means of horizontal rather than vertical piers.
100 to __ (Undefined)	Very high lift	0	These projects are outside the range of CE lock operational experience (Plate 1-1); the exception in John Day Lock (107-ft lift) on the Columbia River. High-lift designs augmented by analytical and laboratory studies are suggested for preliminary (prior to physical model testing) layout.



Note: Other lateral culvert systems have been used for CE locks (see Appendix B: BL2 is a two-culvert low-lift design and BLC/S and BLC/I are two-culvert high-lift designs). Because of operational limitations, these lateral systems will receive careful review prior to design acceptance.

Figure 1-2. Flow distribution of recommended designs



NOTES: 1. DESIGN DETAILS VARY WITHIN EACH DESIGN TYPE.
2. ORDINATE PERCENTAGES ARE PER DESIGN TYPE.
3. ABSCISSA (LIFT) INCREMENT IS 5 FT.
4. REPORTING PROCEDURE (LIFT AND TYPE) IS IMPRECISE; ALL CE LOCKS ARE NOT INCLUDED.
5. REFER TO EP1105-2-11 AND APPENDIX B FOR PROJECT INFORMATION.
6. ⊢####### INDICATES OVERLAPPING OF DESIGN TYPES.

HISTOGRAMS
CE LOCK OPERATION EXPERIENCE

PLATE 1-1